



Digital twins

Better outcomes
from connected data

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What is a digital twin?¹

Digital twins are realistic digital representations of physical things. They unlock value by enabling improved insights that support better decisions, leading to better outcomes in the physical world. What distinguishes a digital twin from any other digital model is its connection to the physical twin. Based on data from the physical asset or system, a digital twin unlocks value by supporting improved decision making, which creates the opportunity for positive feedback into the physical twin.

For example:

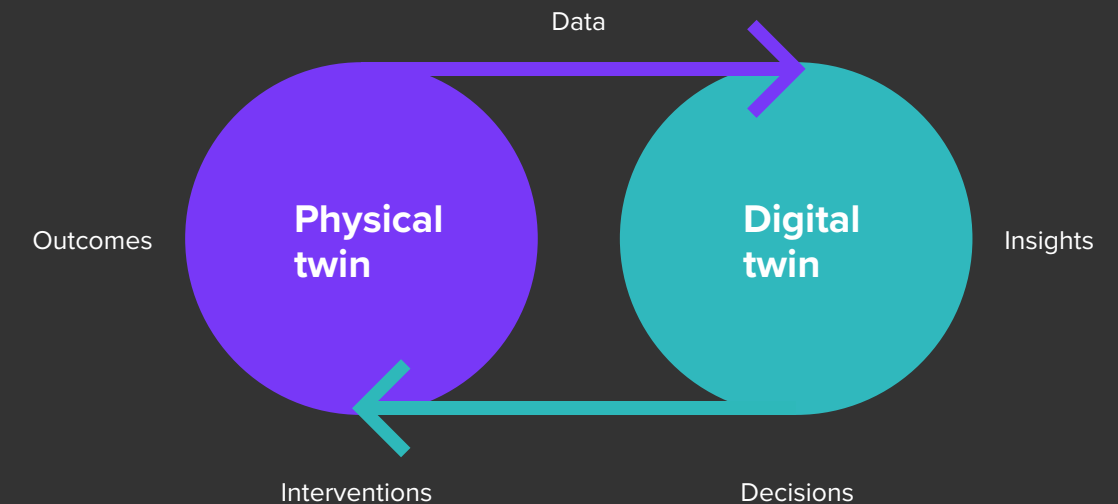
- Digital twin 1: A dynamic model of an asset, with input of current performance data from the physical twin via live data flows from sensors; feedback into the physical twin via real-time control.
- Digital twin 2: A static strategic planning model of a system, with input of long-term condition data from the physical twin via corporate systems; feedback into the physical twin via the capital investment process.

Fundamental requirements of a digital twin are that it must have clear purpose, be trustworthy, and function effectively.

Appropriate detail

A digital twin must represent physical reality at a level of accuracy suited to its purpose. The extent of realism depends on three essentials:

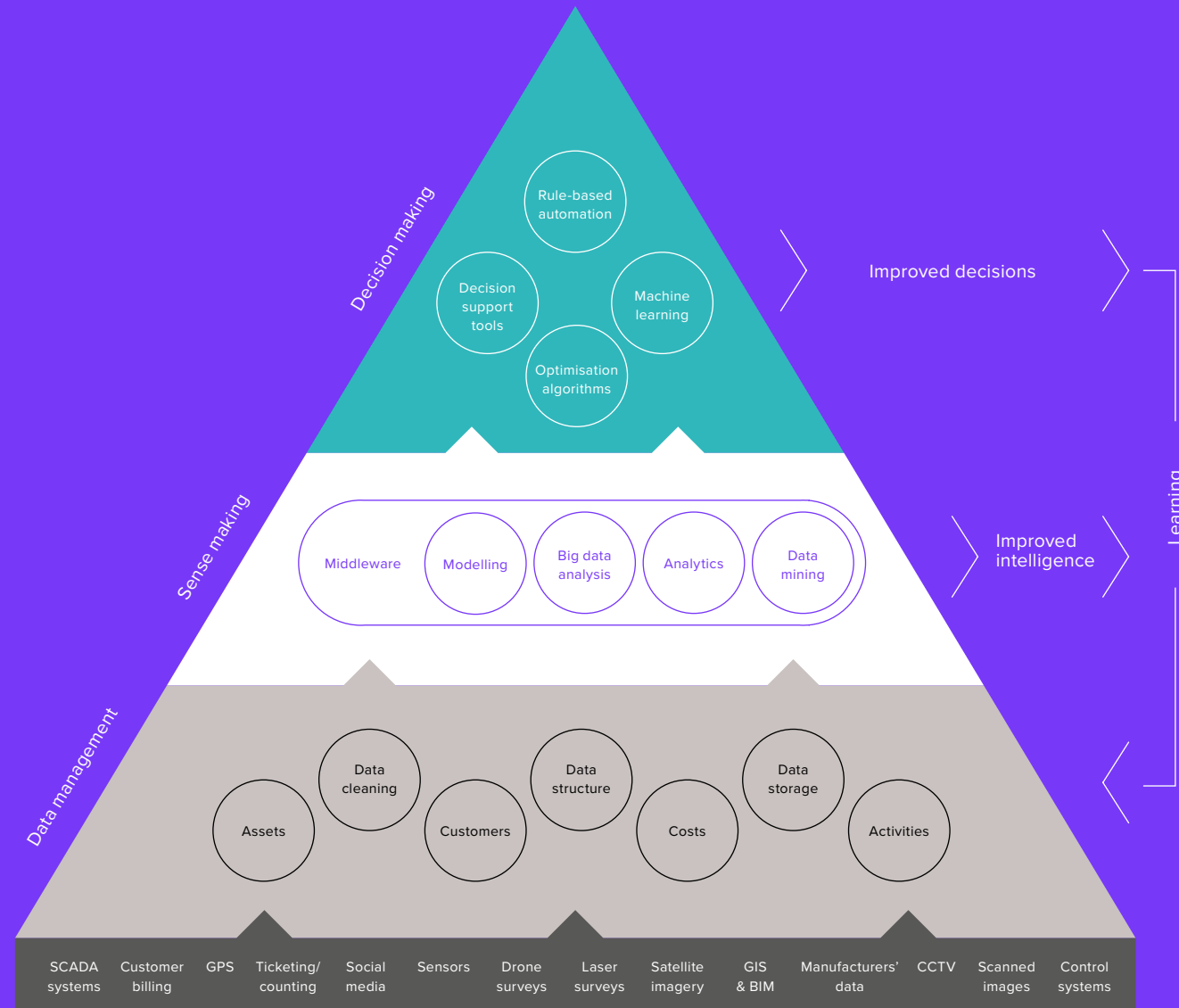
- Data – the quality of the data on which the twin is based.
- Model – the fidelity of the algorithms, the validity of the assumptions and the competence of the code at the heart of the digital representation.
- Visualisation – the quality of presentation of the output. Digital twins may be developed for a range of purposes, operate at different scales or adopt different approaches to modelling.



¹ This definition is from The Gemini Principles, published by the Centre for Digital Built Britain, 2018.

The information value chain

Digital twins enable you to make the most of the information value chain for better performing assets. It all begins with data – from the assets you manage, your customers, adjacent infrastructure, and other data sources. Better gathering, management and use of this data leads to better insights into asset condition and performance. These insights support better decisions which in turn lead to better interventions. The end result is better outcomes for you and your customers.



See.
Act.
Impact.

Combining digital solutions with physical assets leads to smart infrastructure. Digital twins are a key element of this, and the benefits are summed up in our smart infrastructure value proposition: See. Act. Impact.

See the unseen: Accurate visualisations of physical assets based on real-time data provide owners and operators with a greater understanding of the condition and performance of their assets. Analysis of long-term data provides insight into service provision and customer demand, enabling asset managers to plan ahead.

Act with conviction: The real value of digital twins lies in their supreme ability to support better decisions. Maintenance moves from reactive to pre-emptive, and accurate information de-risks long-term investment decisions. Real-time updates mean the effect of decisions can be measured, monitored and optimised.

Impact progress: Better decisions result in better interventions, leading to better economic, social and environmental outcomes for the client and the ultimate customer. The model also enables scenario planning and optioneering for future development.

Key drivers

Population growth and urbanisation: Larger and denser urban populations put greater pressure on existing assets, infrastructure and natural systems.

Climate change: The urgent need to drive down carbon emissions and meet the demands of the Paris Agreement mean radical efficiencies must be achieved, while adapting and creating resilience to unavoidable climate change effects.

Social development: Governments and the infrastructure industry face ever increasing demands for better service at lower cost. Infrastructure also plays a direct or indirect role in all of the UN's 17 Sustainable Development Goals which steer the global community towards meeting clear economic, social and environmental milestones.

Limited resources: Lack of space, constrained finance and finite resources mean we can't rely on physical solutions to meet these challenges. We must innovate in the way we view and use the existing infrastructure base.

Variety in digital twins

1. Variety of purposes

Digital twins can be used for many purposes:

- a. Potential futures: Strategy and planning support, running 'what if?' scenarios, predictive and preventive maintenance regimes
- b. Current state: Intervention management (operation and maintenance interventions or capital investment projects), real-time status monitoring and control, diagnostics and prognostics to optimise performance and safety of assets
- c. History: Record-keeping and learning from the past

2. Variety of spatial scales

Digital twins may address a variety of spatial scales, including:

- a. Asset or building scale
- b. Network or neighbourhood scale
- c. System, city or regional scale
- d. National scale

3. Variety of temporal scales

Digital twins may represent any point in the lifecycle of assets, processes and systems. They can be static or dynamic and may address different temporal scales, including:

- a. Operational timescale
- b. Reactive maintenance timescale
- c. Planned maintenance timescale
- d. Capital investment timescale

4. Variety of approaches to modelling

Digital twins may use different approaches to modelling, including:

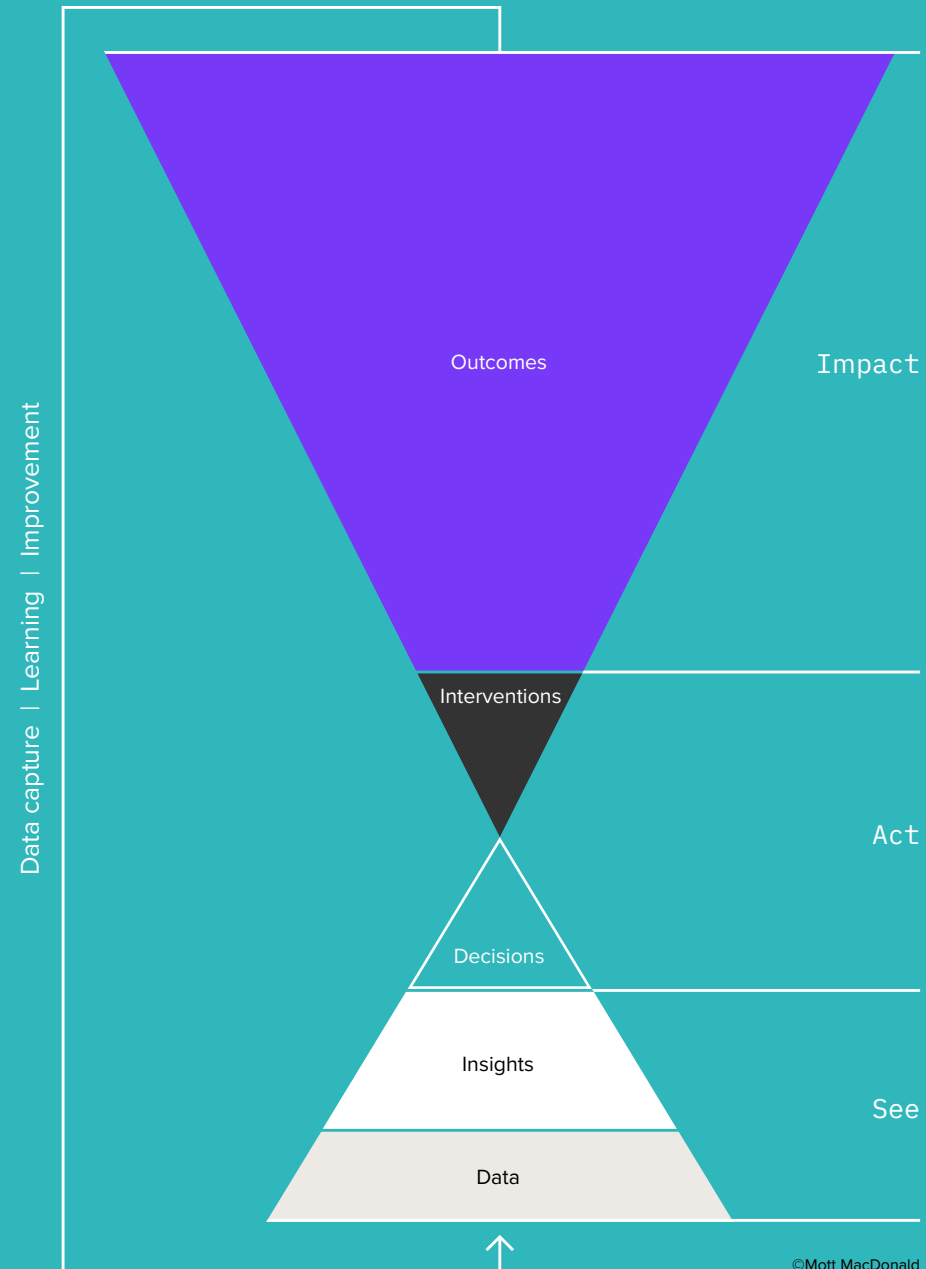
- a. Geometric and geospatial modelling
- b. Computational/mathematical/numerical modelling
- c. Artificial intelligence and machine learning

The positive outcomes of digital twins can be direct, indirect and induced:

Direct outcomes: Usually the easiest to quantify, direct benefits are the positive impacts on asset performance, the overall enterprise and the customers who benefit.

Indirect outcomes: The positive impact on adjacent assets, businesses and wider society which benefit from high-performing infrastructure in one part of the 'system of systems'.

Induced outcomes: Potential growth or value creation enabled by wider ripple effects.



Who benefits?

Customers: Service is improved, without raising bills/fares. Customers' data informs policy, strategy, planning and execution, improving engagement, trust and contentment.

Society: Twins promote economic growth, environmental quality and social inclusion. By making complex interactions easier to understand, isolated and systemically connected risks can be addressed, facilitating effective mitigation and the creation of social resilience.

Owners/operators: Twins enable better investment, efficient asset management, improved customer service and effective risk reduction. The enterprise is more sustainable, with a virtuous cycle of improved service leading to stronger reputation, better business and improved access to capital.

Governments/local authorities: Better performing assets reduces the need for new build solutions, meaning money can go further. Digital twins aid scenario planning for future strategic investment decisions.

Investors/lenders: Digital twins can be used to simulate the effects of proposed investments and for design optioneering, optimising the use of funds and reducing risk. Investors and lenders also benefit from long-term asset performance data to back up financial decisions and to support the business case for further investment.

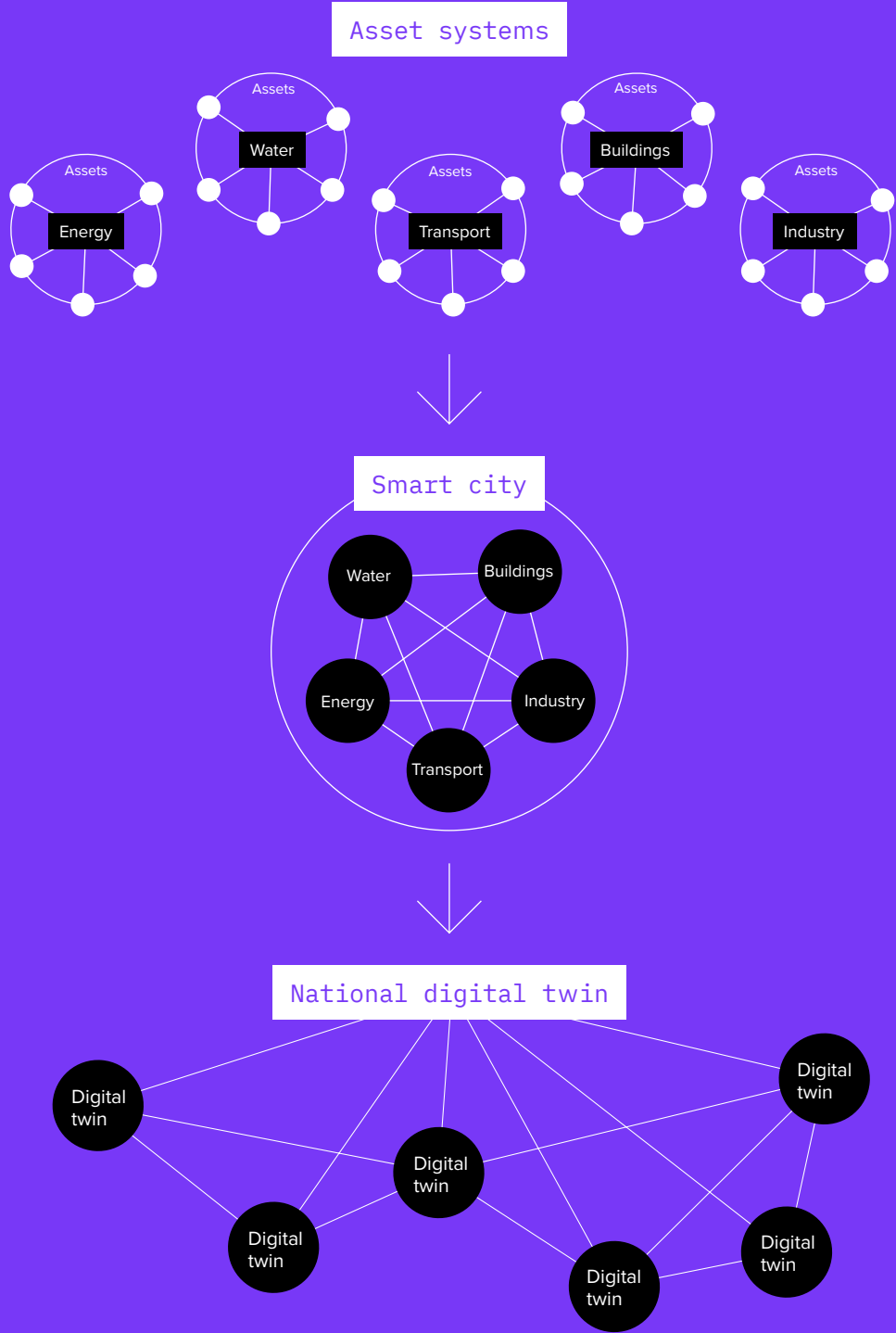
Twins united

The data at the heart of each and every twin can be used to create additional twins. Removing the technological, commercial and cultural barriers to effective data sharing enables data to be exchanged between them, and for twins to be federated. Using data combined from different twins can enable additional models to be created. Federating models to provide new insights and efficiencies enables the value of data to be multiplied.

Federating twins makes absolute sense at an organisational scale. If organisations co-operate beyond their own boundaries, linking with one-another’s models and sharing data between them, then the value multiplies still further.

The National Infrastructure Commission’s report ‘Data for the public good’ recommended the development of a national digital twin (NDT), which will become an ecosystem of digital twins connected by securely shared data. Consultant Deloitte estimated the additional value to the UK economy alone at £7bn per year, gained through improved performance and service quality².

² ‘New technologies case study: data sharing in infrastructure’, 2017



Managing entire asset systems will bring greater efficiency and oversight.

A smart city brings together its entire asset base as a 'system of systems'.

Interoperability between asset systems will allow better decision making and greater efficiencies.

A national digital twin is an ecosystem of the country's digital twins connected via securely shared data.

The Gemini Principles

As the industry has learned using building information modelling (BIM), setting clear definitions and principles for information management is essential to achieve the interoperability and durability essential to realising the greatest value from digital twins.

The Digital Framework Task Group (DFTG) brought together stakeholders from government, industry and academia to build consensus on the definitions and values for information management that will guide the development of digital twins – the Gemini Principles.

They are descriptive of intent, but agnostic on solutions, so they are meant to encourage flexibility for innovation and development over time.

The invitation is to start unlocking value for your organisation, customers and society, using data. What can digital twins do for you?

Purpose:
Must have clear purpose

Trust:
Must be trustworthy

Function:
Must function effectively

Public good
Must be used to deliver genuine public benefit in perpetuity

Value creation
Must enable value creation and performance improvement

Insight
Must provide determinable insight into the built environment

Security
Must enable security and be secure itself

Openness
Must be as open as possible

Quality
Must be built on data of an appropriate quality

Federation
Must be based on a standard connected environment

Curation
Must have clear ownership, governance and regulation

Evolution
Must be able to adapt as technology and society evolve



Boosting health outcomes in Sheffield

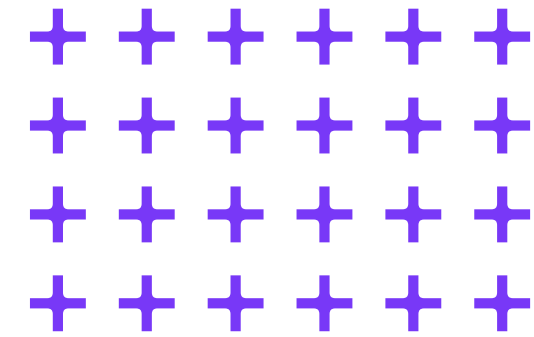
We worked with the Urban Flows Observatory at the University of Sheffield to develop a foundational digital twin as part of the university's plan to boost health outcomes for the city. Digitising infrastructure into a 3D model and integrating live data feeds including air quality and weather gives clearer insight into the factors affecting local health, enabling better strategic decision making. Sheffield's digital twin has been created in line with the Gemini Principles and is a first step towards a comprehensive visualisation, analytics and prediction platform and ultimately a city-wide digital twin.

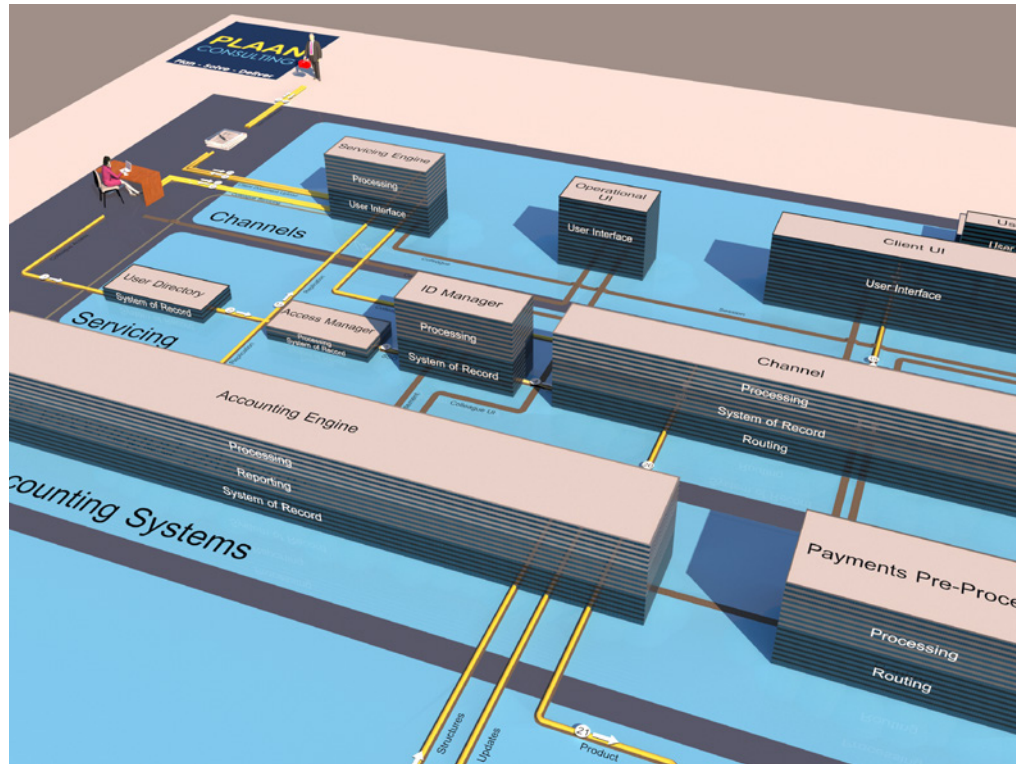
Transforming asset management at Five Fords

We developed a proof of concept digital twin for Welsh Water's £37M Five Fords Wastewater Treatment Works to challenge traditional commissioning and operating procedures and provide actionable insight into asset performance. Built upon our Moata digital twin platform, this model integrates real-time performance data from the treatment process, wastewater modelling, cloud-based data management, and analytics

– enabling users to predict, simulate and implement operational changes in a safe environment. The main benefits will be seen in the operational life of the asset, with greater asset insight supporting:

- Optimisation of wastewater treatment and associated energy production
- Improved operational decision making
- More efficient asset management
- Better-informed strategic investments





Giving 350,000 swimmers the best of Auckland's beaches

After heavy rain in Auckland, New Zealand, sewage networks can overflow and pollute the city's harbours. Swimmers don't know where it's clean and safe to go into the sea. We pinpointed 10 invaluable data streams, including final effluent quality, network hydraulics, weather data and tidal movements. These gave us 1bn data points which are brought together through Moata,

our digital twin platform, where they are analysed every single day to show us the water quality across 84 different beaches. The result is a public-facing platform called Safeswim that helps 350,000 people enjoy Auckland's waters all year round. Armed with this vital real-time data on its wastewater infrastructure, Auckland Council is investing to build a better network for the future.

Simplify complex information with Contex-City

Large IT implementation or structural change programmes are notoriously difficult. Users and beneficiaries can struggle to visualise how the system works and their role within it. Plaan Consulting approached us with a vision for Contex-City that sets out to change that by creating an interactive 3D world that acts as a visual representation of the enterprise – its processes, people and technology. We brought our skills in modelling infrastructure systems, implementing complex programmes and envisioning information. The unique user experience provides all parties with greater understanding of the status, location and relationships that exist between their assets and how they interact with them. This enables them to quickly understand issues, identify respective owners, pinpoint areas of weakness and examine 'what if' scenarios.



Where can Smart
Infrastructure
take you?

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For more information on how digital twins can benefit your business,
contact our Smart Infrastructure team: smart@mottmac.com

smartinfrastructure.com